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(54) **Hand tool which generates vibrations eg a drill or chisel**

(57) Arranged between housing (11), and handle (12) connected displaceably thereto, are compression springs (14) as well as a spring system which consists of levers (15) and springs (18) and whose force (F2) acting in the direction of displacement of the handle (12) varies complementarily to the force (F1) of the compression springs (14). The resultant force (K), consisting of the sum of the two forces (F1) and (F2) applied at the handle thus remains constant over the entire path of displacement of the handle (12). In this way transmission of the vibrations, generated in the housing (11), to the handle (12) is prevented.

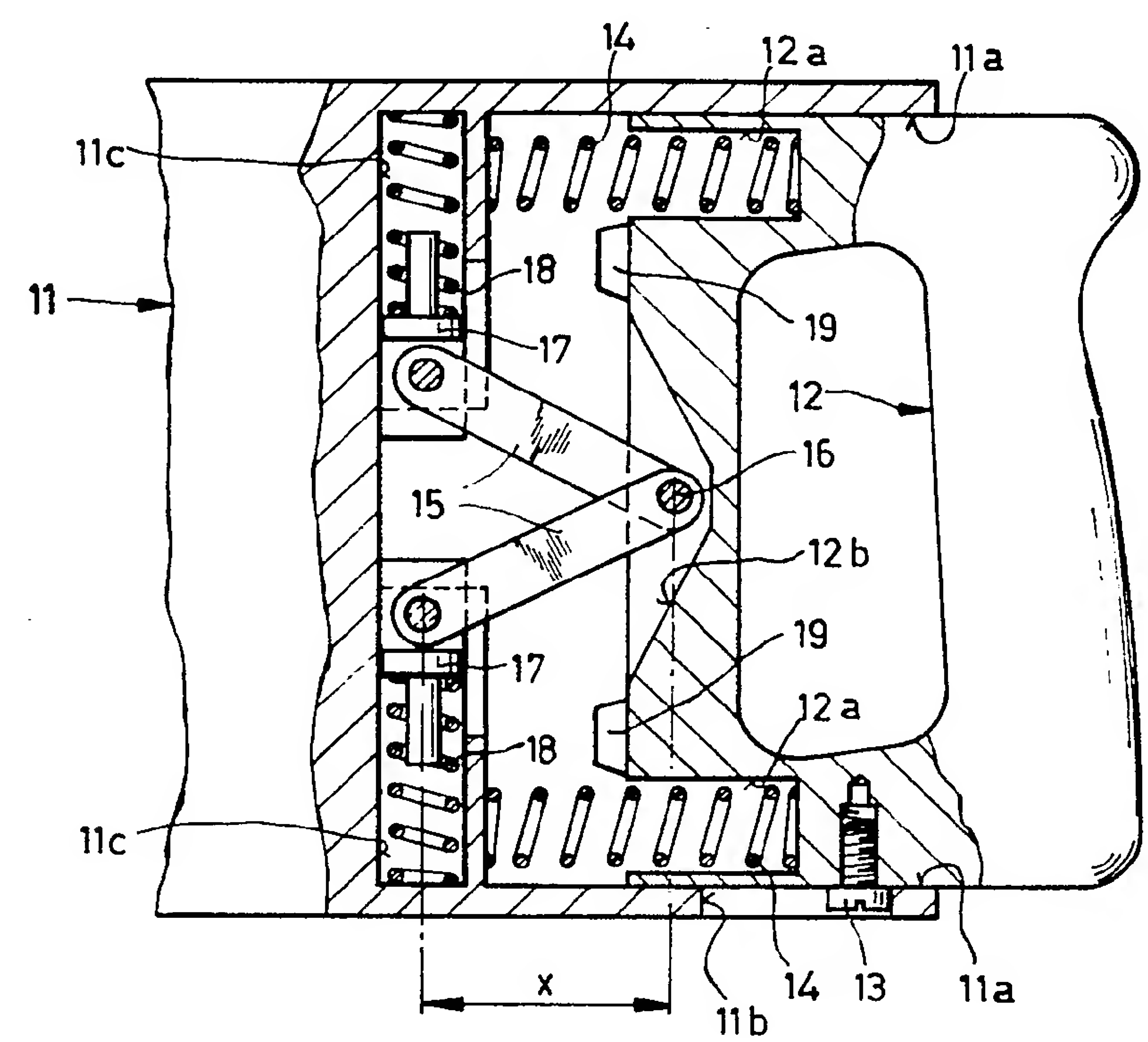

Fig.3

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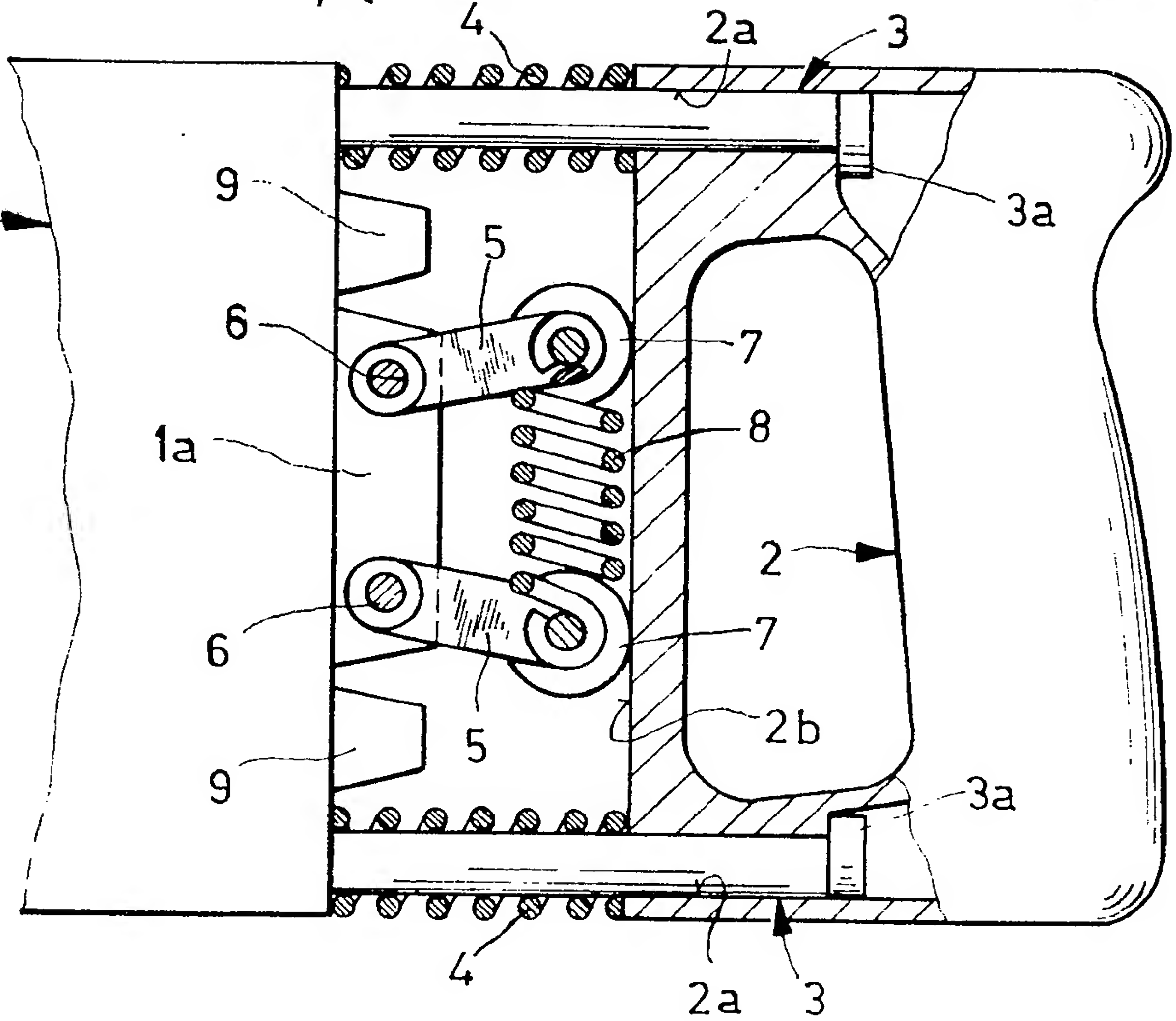
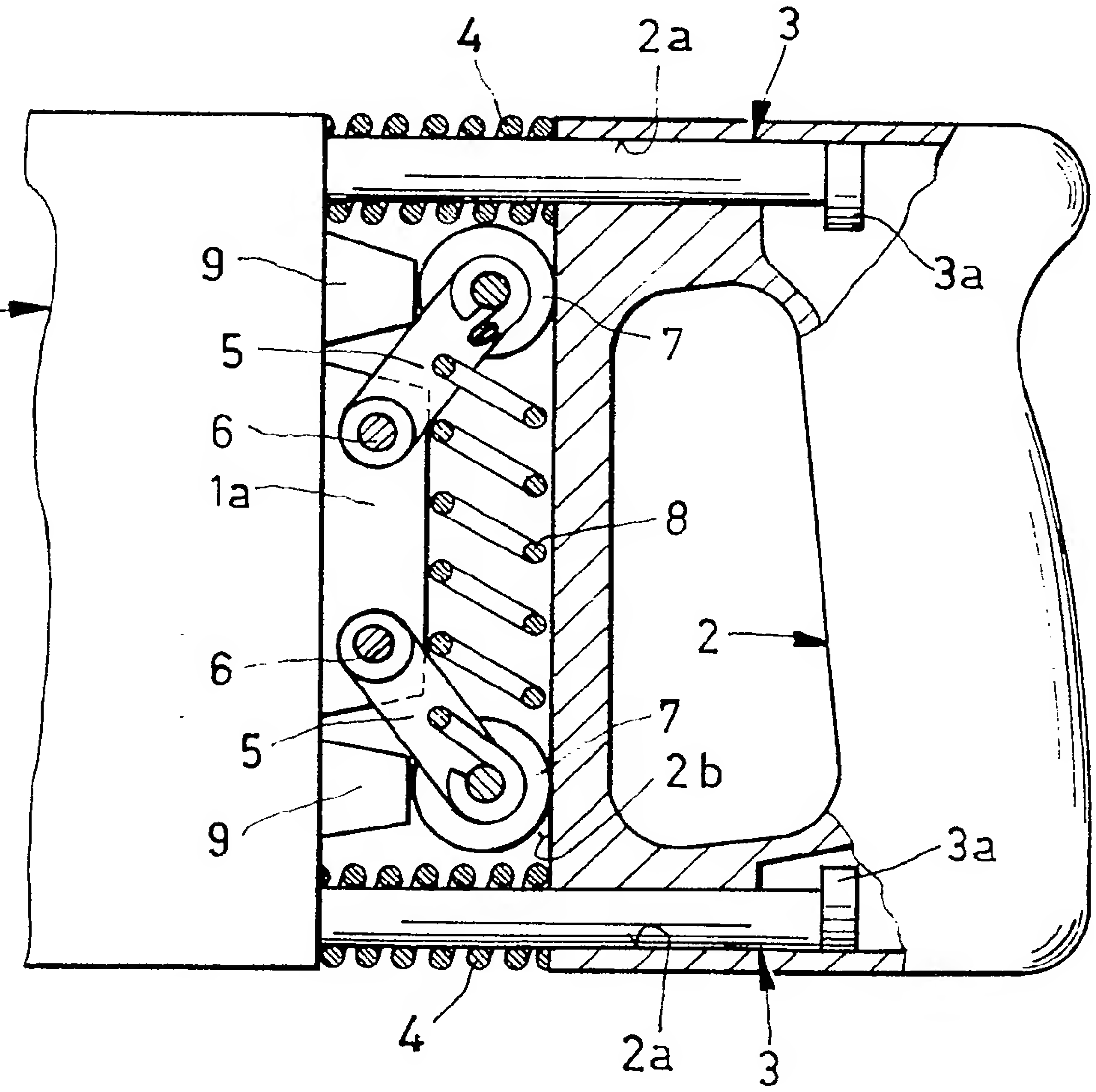

4
2a
3
3a
9
1
5
6
7
8
1a
2
6
7
2b
5
9
3a
4
2a
3

Fig.1


4
2a
3
3a
9
1
7
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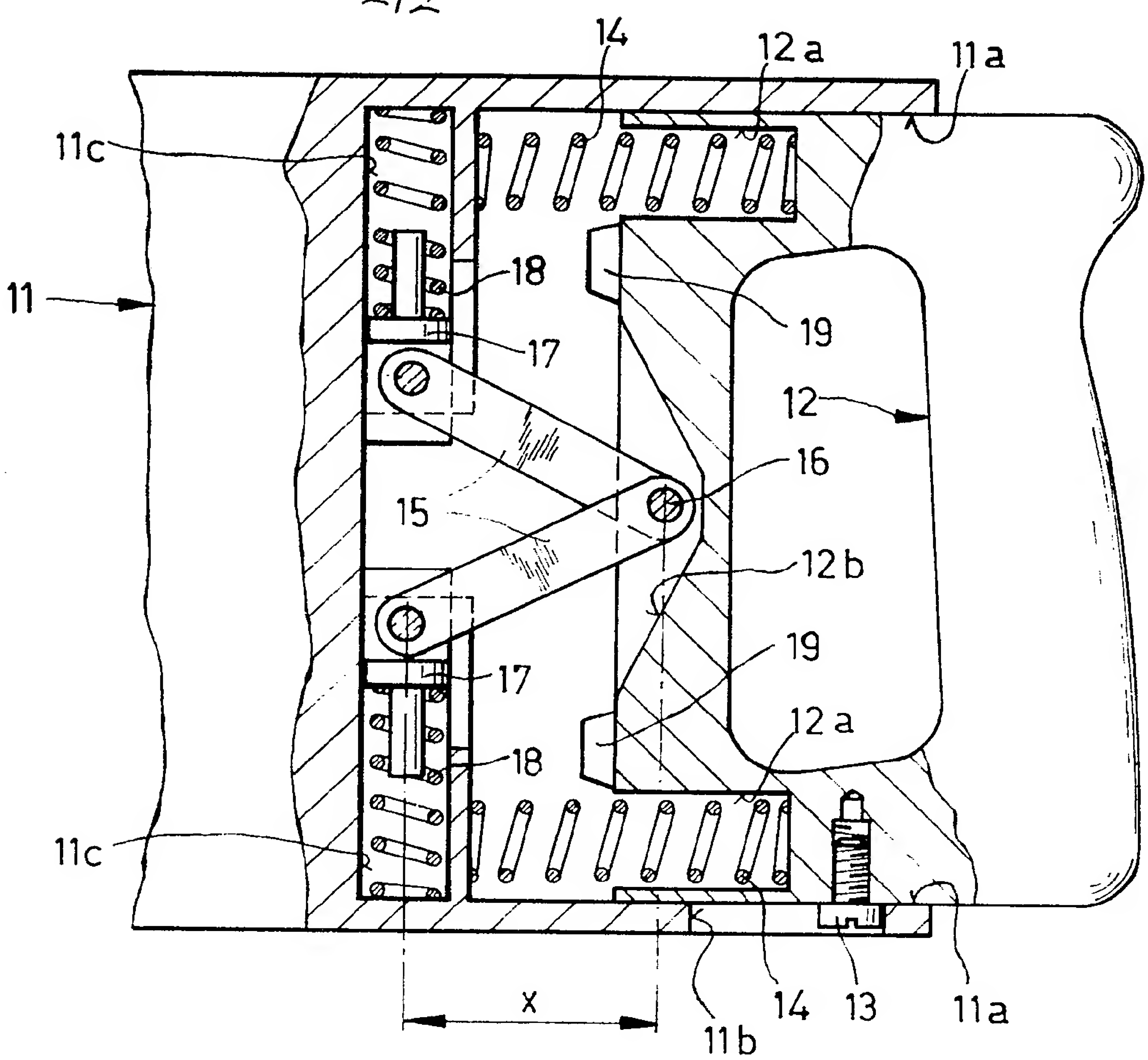
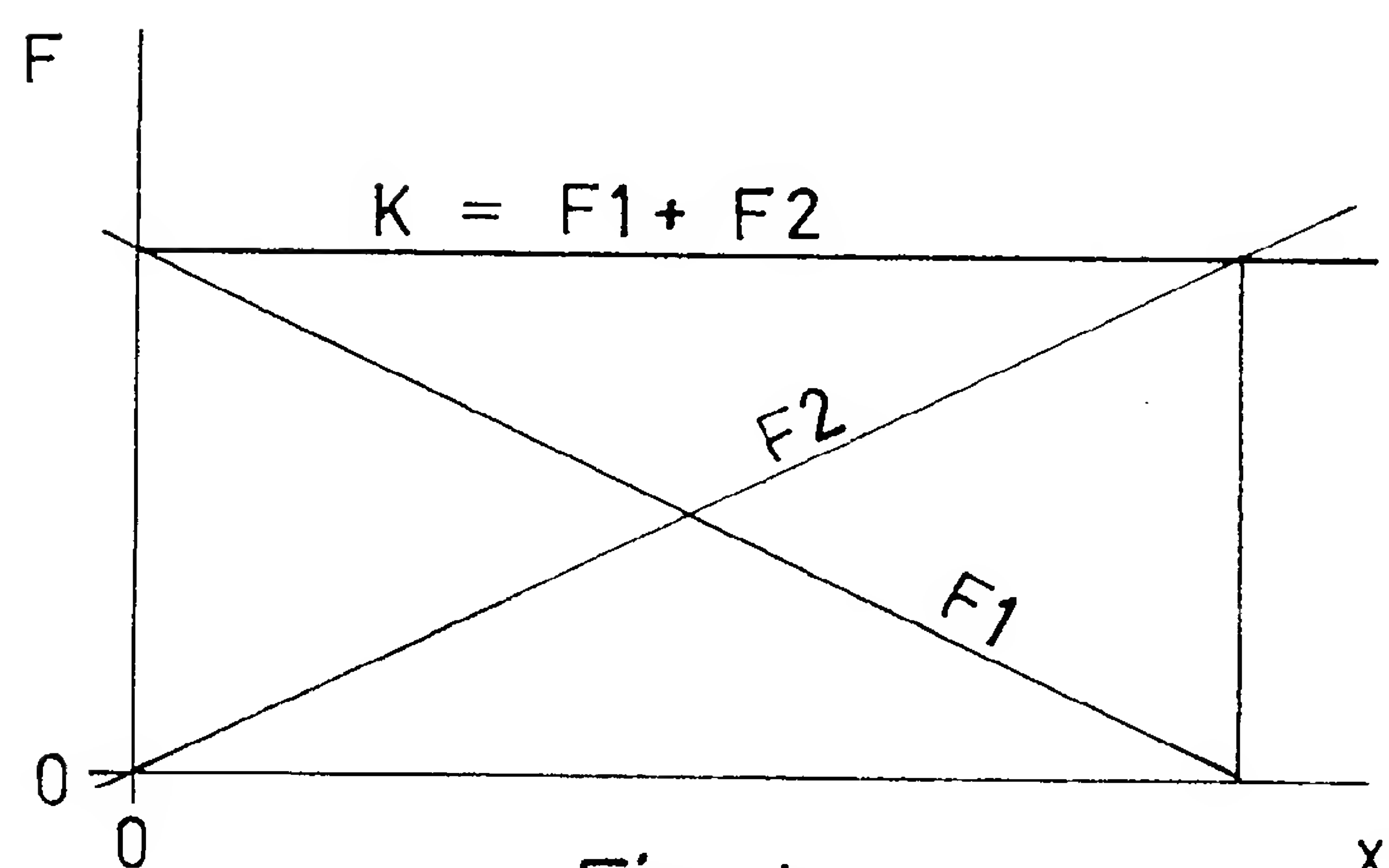
8
2
6
7
5
2b
9
3a
4
2a
3

Fig.2



14
12a
11a
11c
18
11
19
17
12
16
15
12b
19
17
12a
18
11c
x
11b
14
13
11a

Fig. 3



F
K = F1 + F2
F2
F1
0
0
x

Fig. 4

SPECIFICATION

A hand tool which generates vibrations

The invention relates to a hand tool having a drive mechanism which is arranged in a housing and which generates vibrations, and having a handle which is connected to the housing so as to be displaceable parallel to the main axis of vibration against the force of spring elements.

Hand tools of the kind having a drive mechanism which generates vibrations are mainly used in the building trade as pick, drill and chisel hammers. The vibrations may be generated electromechanically (i.e. by means of an electric motor and a mechanical or electropneumatic percussion mechanism) purely pneumatically, hydraulically or electromagnetically, and they act, for example, on a drilling or chiselling tool. Because of reaction forces, these vibrations are transmitted, in the known hand tools, by way of the handle, to a greater or lesser extent to the hand/arm system of the operator. The alternating loading and relaxing of the joints and muscles which occurs during operation of the tool can lead, in the course of time, to damage of the operator's health. Depending upon the type of tool involved, and the working position of the tool, a relatively great force has to be applied by the operator for pressing against or following-up of the tool. After a short time, operators can experience severe fatigue through the vibrations which are superimposed on pressure applied by the operator, so that, for example, the drilling or picking performance deteriorates severely if the operator has to keep the tool in continuous operation.

In order to lessen the transmission of the vibrations from the hand tool to the operator, it is known not to connect the hand tool rigidly to the housing, but to support the same relative to the housing so as to be displaceable parallel to the main axis of vibration against the force of spring elements. Although these spring elements have a certain damping effect, it has, so far, not been possible to prevent the transmission of the vibrations completely. A disadvantage of such spring elements lies in the fact that they have a certain inherent frequency, and thus can, for example in the case where the frequency of the drive mechanism changes in operation, lead to onerous resonance phenomena.

Since it is known to avoid the transmission of vibrations from the housing to the handle when the force transmitted from the housing to the handle (and *vice versa*) is constant irrespective of the amplitude of displacement of the handle, in a known tool an attempt has been made to achieve such a constant force by using a special design for the springs, by using a combination of different springs and by use of special lever systems. In all of these solutions, the handle is connected to the housing by way of a swivel arm and a hinge or joint. Thus, the handles of these tools do not carry out a linear movement, but a swivel movement about the joint. The force resulting from these systems, at the handle, remains constant only over a small part of the path of displacement. Thus, even in the case of this known tool, if the handle moves outside this region, vibrations are transmitted from the housing to the handle.

The problem underlying the invention is to provide a tool having a drive mechanism which generates vibrations, in which transmission of the vibrations from the housing to the handle is prevented or minimised.

In accordance with the invention, this problem is solved by the provision of an additional spring system which consists of springs and levers and which isolates the handle from the vibrations of the housing and whose force resultant parallel to the main axis of vibration varies over the path of displacement of the handle complementarily to that of the spring elements.

Thus, for example, when, upon the displacement of the handle relative to the housing in the one direction, the force of the spring elements increases, there is simultaneous decrease of the force resultant, parallel to the main axis of vibration, of the spring system consisting of springs and levers and *vice versa*. The force arising by summation of the two forces, and to be applied to the handle, thus remains substantially constant even substantially the entire path of displacement.

In an advantageous embodiment of the invention, the levers of the spring system are connected at the one end swingably to the housing, are mounted so as to be displaceable at the other end, in the handle, transversely to the direction of movement of the handle relative to the housing, and are connected to one end of the springs. The levers are thus associated with the housing and are connected thereto. This makes it possible to achieve a good, stable mounting of the levers and facilitates, for example, removal or exchange of the handle.

If the other end of the levers is supported displaceably on the handle, it is advantageous also to support the other end of the springs of the spring system on the handle. This permits good transmission of the forces to the handle.

In a further advantageous embodiment, the levers of the spring system are connected swingably at one end to the handle; at the other end they are mounted so as to be displaceable transversely to the direction of movement of the handle relative to the housing and are connected to one end of the springs. The levers are in this case closely associated with the handle and can, for example, be pre-assembled together therewith

as a structural unit.

If the other end of the levers is arranged displaceably on the housing, it is advantageous also to support the other end of the springs of the spring system on the housing. The supporting of the levers on the housing can, in this respect, at the same time serve as lateral guidance of the springs of the spring system.

Considerable forces can occur at the levers and springs of the lever system. In order to avoid one-sided loading, it is therefore advantageous to arrange the levers so as to be swingable in contrary directions in pairs. With such a pairwise arrangement of the levers, the lateral forces occurring transversely to the direction of movement of the handle neutralise one another or mutually cancel one another out. Depending on the size and position of the levers, it is possible to employ several pairs of levers, arranged side-by-side. Such an arrangement makes possible a compact type of construction, in that the forces to be applied and the forces to be absorbed can be distributed to several levers and respective springs.

Depending on the space available and the desired path of displacement of the handle, different springs can be used for the spring system. An advantageous version consists in designing the springs of the spring system as compression springs. Compression springs make possible a compact type of construction and relatively large spring paths. Compression springs are relatively simple to assemble and fit and can, therefore, also be exchanged simply and rapidly. An additional advantage of compression springs consists, moreover, in that they make possible adjustment of the bias, for example by means of adjusting screws.

A further advantageous proposal consists in designing the springs of the spring system as tension springs. Tension springs, more especially together with a pairwise arrangement of the levers, make possible a particularly simple type of construction in that the ends of the tension springs are connected to the free ends of a pair of levers. In this way, one achieves an arrangement in which the same tension spring acts simultaneously on two different levers. The tension springs are thus arranged between the free ends of the levers. With such an arrangement of the tension springs, transversely to the direction of movement of the handle relative to the housing, no forces are transferred to the handle or to the housing.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a fragmentary part-sectional side elevation illustrating a preferred embodiment of the hand tool in accordance with the invention, in its condition not pressed towards material to be worked;

Figure 2 is a view comparable with Fig. 1, but showing the tool in its condition pressed towards material being worked;

Figure 3 is a view similar to Figs. 1 and 2 but showing a second embodiment of the hand tool in accordance with the invention; and

Figure 4 is a force/path diagram applicable to the hand tool of Fig. 3.

The hand tool shown in Figs. 1 and 2 comprises a housing which is designated as a whole by the reference numeral 1 and a handle which is connected displaceably thereto and which is designated as a whole by the numeral 2. The handle 2 has longitudinal guides *2a* for guide rods which are designated as a whole by numeral 3 and which are connected to the housing 1. Compression springs 4 arranged between the housing 1 and the handle 2 surround the guide rods 3 and are guided thereby. An initial position, shown in Fig. 1, of the handle 2 is limited by stops *3a* on the guide rods 3. Two levers 5 are hinged to a bearing block *1a* of the housing so as to be swingable about axes 6. The free ends of the levers 5 are connected to rollers 7 which are supported on a run-up surface *2b* of the handle 2. The free ends of the levers 5 are, moreover, connected to one another by a tension spring 8, the length of which, in the relaxed state, corresponds approximately to the spacing of the hinge points of the levers 5 or of the axes 6.

Upon the application of a force, acting in the direction of movement of the handle 2, at the handle and of a corresponding counterforce at the housing 1, the handle 2 is shifted, along with tensioning of the compressions spring 4 and of the tension spring 8, towards the housing 1. Upon approach of the handle 2 towards the housing 1, the resistance of the spring 4 increases. In this respect, the levers 5 are swung out concurrently, along with simultaneous tensioning of the tension spring 8. Since the levers 5 form, in principle, an elbow-lever system, the resistance, acting in the direction of movement of the handle 2, of the spring system formed by the levers 5 and the tension spring 8, however, progressively decreases. With appropriate harmonising of the springs 4 with the spring system formed by the levers 5 and the tension spring 8, the result can be achieved that the force necessary for the displacement of the handle 2 remains constant over the entire path of displacement.

The maximum pressed or squeezed position, shown in Fig. 2, of the hand tool shows, compared with Fig. 1, the deflection of the levers 5 along with simultaneous tensioning of the compression springs 4 and of the tension spring 8. The front end position of the handle 2 is limited by buffers or pads 9 against which the rollers 7 come into abutment. Upon release of the handle 2 or when contact pres-

sure diminishes to below the constant force afforded by the system, the handle 2 is brought back by the compression springs 4, along with simultaneous relaxation of the tension spring 8, again into the initial position shown in Fig. 1.

The hand tool which is shown in Fig. 3 comprises a housing which is designated as a whole by numeral 11 and a handle which is connected displaceably thereto and which is designated as a whole by numeral 12. The housing 11 has a guide 11*a* for the handle 12. The displaceability of the handle 12 is limited by a stop screw 13 in the handle 12 and a slotted hole 11*b*, surrounding the head of the stop screw 13, in the housing 11. Mounted in reception bores 12*a* of the handle 12 are compression springs 14 which are supported in the axial direction on the one hand on the housing 11 and on the other hand on the handle 12. Levers 15 are mounted in a recess 12*b* of the handle 12 so as to be swingable about an axis 16. The free ends of the levers 15 are connected to pistons 17. The pistons 17 are mounted so as to be axially displaceable in bores 11*c* of the housing 11. Upon displacement of the handle 12 relative to the housing 11, the pistons 17 are displaced axially against the force of springs 18. Thus, in the case of this solution, too, upon approach of the handle 12 towards the housing 11 the compression springs 14 and the springs 18 are tensioned. Since the levers 15 form an elbow-lever system, the resistance of the spring system, formed by the springs 18 and the levers 15, decreases upon approach of the handle 12 towards the housing 11, i.e. with a diminishing distance x it correspondingly becomes smaller. The resistance or the force of the compression springs 14 simultaneously increases. By appropriate harmonising of the compression springs 14, the levers 15 and the pistons 17, the result can be achieved that the resulting force remains constant over the entire path of displacement of the handle 12. Provided on the handle 12 are buffers or pads 19 which, upon the constant force afforded by the system being exceeded, damp the run-up of the handle 12 onto the housing 11.

The force/path diagram evident from Fig. 4 shows the force course of the compression springs 14, arranged in the direction of displacement of the handle 12, over the distance x between the housing 11 and the handle 12. F1 denotes the force which is generated by the two springs 14 and which with $x=0$, i.e. with the handle 12 running-up against the housing 11, is greatest and with the distance x becoming larger can drop right down to 0.

On the other hand, F2 shows the force, resulting from the spring system, in the direction of displacement of the handle 12. This force F2 decreases with the distance x becoming smaller, i.e. upon the stretching of the elbow-lever system formed by the levers 15.

Since the two forces F1 and F2 vary intensely or complementarily, the resulting force K, consisting of the sum of these forces and to be applied at the handle 12, remains constant over the entire path of displacement of the handle 12.

The length of the levers 15 or the position of the hinge point formed by the axis 16 can also be so selected that, upon the displacement of the handle 12, the elbow lever consisting of the levers 15 oscillates about the stretch position. In the stretched position of the elbow lever, i.e. when the mass x becomes$=0$, also the force F2 of the spring system is equal to zero. If the elbow lever is deflected onto the other side, then the force F2 becomes negative, i.e. it acts in the opposite direction. Since, in this respect, F1 increases, in this region too the resulting force K remains constant.

Purely theoretically, the handle can be isolated completely from the vibrations of the housing. In practice, however, disturbing influences exist, however, through friction in the bearings and mass inertia of the moving parts. In order to keep these influences slight and to make possible good vibration isolation, the bearing friction has to be kept low for example through roller bearings and the masses of the moving parts have to be kept small.

CLAIMS

1. A hand tool having a drive mechanism which generates vibrations and which is arranged in a housing and having a handle which is connected to the housing so as to be displaceable parallel to the main vibration axis against the force of spring elements, characterised by a spring system which consists of springs and levers and which isolates the handle from the vibrations of the housing and whose force resulting parallel to the main axis of vibration varies over the path of displacement of the handle complementarily to that of the spring elements.

2. A tool as claimed in claim 1, characterised in that the levers of the spring system are at one end connected swingably to the housing, at the other end are displaceably mounted in the handle transversely to the direction of movement of the handle relative to the housing and are connected to one end of the springs.

3. A tool as claimed in claim 2, characterised in that the other end of the springs of the spring system is supported on the handle.

4. A tool as claimed in claim 1, characterised in that the levers of the spring system at the one end are connected swingably to the handle, at the other end are displaceably mounted in the housing transversely to the direction of movement of the handle relative to the housing, and are connected to one end

of the springs.

5. A tool as claimed in claim 4, characterised in that the other end of the springs of the spring system is supported relative to the housing.

6. A tool as claimed in any preceding claim characterised in that the levers are arranged so as to be swingable in opposite directions in pairs.

7. A tool as claimed in any preceding claim characterised in that the springs of the spring system are designed as compression springs.

8. A tool as claimed in any preceding claim characterised in that the springs of the spring system are designed as tension springs.

9. A hand tool substantially as hereinbefore described with reference to and as illustrated in Figs. 1 and 2, or in Fig. 3 of the accompanying drawings.

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